

WHAT IS CLAIMED IS:

1. A color image processing method comprising the steps of:

edge-detection of a digital color original image
5 obtained by digitally inputting a single side of a document
color-printed on both sides of paper;

estimating background color of said paper or
background color image on said single side with respect to
a portion with low intensity of said detected edge;

10 performing color threshold processing in which said
portion with the low edge intensity as a component
corresponding to the show-through is replaced with said
estimated background color or background color image in said
original image; and

15 generating a show-through removed image as an image
from which the component corresponding to the show-through
has been removed.

2. The color image processing method according to claim
20 1, wherein the edge-detection is performed by calculating
edge intensity from each component of an image in which the
edge is detected and considering a correlation between
respective edge intensity of said components.

3. The color image processing method according to claim 1, wherein the color threshold processing including the steps of:

binarizing the edge intensity;

5 in edge distribution in which a pixel with the edge intensity higher than a threshold is obtained as an ON pixel and a pixel with the edge intensity lower than the threshold is obtained as an OFF pixel,

setting a window of a predetermined size in a region
10 of said OFF pixels;

classifying the pixels within each window into two colors;

estimating a color with higher brightness of said two colors as a background color;

15 replacing the color of the pixels within each of said windows with said estimated background color; and

replacing said original image with said background color image.

20 4. The color image processing method according to claim 3, wherein the color threshold processing further including the steps of:

forming a run in each line in a horizontal (or vertical) direction with respect to the region of said OFF pixels;

25 estimating said background color or background color

image using the horizontal (or vertical) runs;

forming a run in each line in a vertical (or horizontal)
direction with respect to said estimated background color
or background color image in the horizontal (or vertical)
5 direction;

estimating a background color or a background color
image using the vertical (or horizontal) runs;

replacing the pixels of said original image
corresponding to said OFF pixels with pixels of said
10 estimated background color or background color image in the
vertical (or horizontal) direction; and

replacing said original image with said background
color or background color image.

15 5. The color image processing method according to claim
3, wherein thresholds in binarization of the edge intensity
are automatically set by statistically analyzing
distribution of the edge intensity.

20 6. The color image processing method according to claim
3, wherein thresholds in binarization of the edge intensity
can be set by a user according to a degree of show-through
or paper quality.

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7. The color image processing method according to claim
1 further comprising the steps of:

detecting an edge of said show-through removed image;
comparing the edge of said detected show-through
5 removed image to the edge distribution of said original
image;

applying again the processing for color threshold
processing to the periphery of an edge not existing in said
original image, in said show-through removed image; and
10 generating a corrected show-through removed image.

8. The color image processing method according to claim
7, wherein, in comparison between the edge of said
show-through removed image and the edge distribution of said
15 original image, edge intensity calculated in said original
image is subtracted from edge intensity calculated in said
show-through removed image at each pixel, and any value
higher than a predetermined threshold is determined, in said
show-through removed image, as an edge not existing in said
20 original image.

9. The color image processing method according to claim
7 further comprising the step of:

setting the size of said window smaller than that in
25 the previous processing when said corrected show-through

removed image is generated.

10. The color image processing method according to claim 1 further comprising the step of:

5 generating a reduced original image with low resolution from said original image;

generating said show-through removed image with respect to said reduced original image;

calculating a difference between said show-through removed image and said reduced original image to estimate a show-through region; and

allocating pixels of said show-through removed image, that correspond to said estimated show-through region, onto said original image with the original resolution.

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11. The color image processing method according to claim 1 further comprising the step of:

transforming the color coordinate system of said original image or said reduced original image to another color coordinate system such as a YCbCr coordinate system or a pseudo KL color coordinate system, in which the components are highly independent from one another;

detecting said edge; and

performing transformation reverse to said transformation on said show-through removed image or said

corrected show-through removed image.

12. A color image processing apparatus comprising:

an edge detection unit which detects an edge in a
5 digital color original image obtained by digitally inputting
a single side of a document color-printed on both sides of
paper;

a background color estimation unit which estimates
a background color of said paper or a background color image
10 on said single side with respect to a low-intensity portion
of said detected edge; and

an image replacement unit which replaces the low
portion of the edge intensity as a component corresponding
to the show-through with said estimated background color
15 or background color image in said original image,

wherein said image replacement unit removes said
component corresponding to the show-through to generate said
show-through removed image.

20 13. The color image processing apparatus according to
claim 12, wherein said edge detection unit calculates edge
intensity from each component of an image in which the edge
is detected, and detects the edge considering a correlation
between the respective edge intensity of said components.

14. The color image processing apparatus according to claim 12, wherein said edge detection unit comprises a binarization unit which binarizes the edge intensity, said background color estimation unit comprises:

5 in edge distribution in which a pixel with the edge intensity higher than a threshold is obtained as an ON pixel and a pixel with the edge intensity lower than the threshold is obtained as an OFF pixel,

a window setting unit which sets a window of a predetermined size in a region of said OFF pixels;

a color clustering unit which classifies the pixels within each of said windows set by said window setting unit into two colors; and

15 an estimation unit which estimates a color with higher brightness of said two colors as a background color, and

said image replacement unit comprises a pixel replacement unit which replaces the color of the pixels within each of said windows with said estimated background color.

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15. The color image processing apparatus according to claim 14 further comprising:

a horizontal run formation unit which forms a run in each line in the horizontal direction in the region of said
25 OFF pixels; and

a vertical run formation unit which forms a run in each line in the vertical direction,

wherein said background color estimation unit estimates said background color or background color image using the horizontal (or vertical) runs formed by said horizontal run formation unit (or vertical run formation unit), further estimates a background color or a background color image using the vertical (horizontal) runs formed by said vertical run formation unit (or horizontal run formation unit) with respect to said estimated background color or background color image in the horizontal (or vertical) direction, and

said pixel replacement unit replaces the pixels of said original image corresponding to said OFF pixels with pixels of said estimated background color or background color image in the vertical (or horizontal) direction.

16. The color image processing apparatus according to claim 14, wherein said binarization unit has an automatic threshold setting unit which statistically analyzes the distribution of the edge intensity and automatically sets the threshold.

17. The color image processing apparatus according to claim 14, wherein said binarization unit has a threshold

setting unit by which a user sets the threshold according to a degree of show-through or paper quality.

18. The color image processing apparatus according to
5 claim 12 further comprising:

an edge determination unit which detects an edge of
said show-through removed image by said edge detection unit,
compares said detected edge of the show-through removed image
and the edge distribution of said original image, and
10 determines an edge not existing on said original image; and

a repetition unit which generates again a show-through
removed image about the periphery of the edge not existing
said original image in said show-through removed image.

15 19. The color image processing apparatus according to
claim 18, wherein said edge determination unit subtracts
edge intensity calculated in said original image from edge
intensity calculated in said show-through removed image at
each pixel, and determines any value higher than a
20 predetermined threshold, in said show-through removed image,
as an edge not existing in said original image.

20. The color image processing apparatus according to
claim 18, wherein said repetition unit sets the size of said
25 window to a smaller value than that in the previous processing

when a show-through removed image is again generated.

21. The color image processing apparatus according to claim 12 further comprising:

- 5 an image reduction unit which generates a reduced original image with low resolution from said original image;
- a show-through region estimation unit which calculates a difference between a show-through removed image generated with respect to said reduced original image and said reduced
- 10 original image to estimate a show-through region; and
- a pixel allocation unit which allocates pixels of said show-through removed image, that correspond to said estimated show-through region, onto said original image with the original resolution.

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22. The color image processing apparatus according to claim 12 further comprising:

- a coordinate system transformation unit which transforms the color coordinate system of said original image
- 20 or said reduced original image to another color coordinate system such as a YCbCr coordinate system or a pseudo KL color coordinate system, in which the components are highly independent from one another; and

- a coordinate system reverse transformation unit which
- 25 performs transformation reverse to said transformation on

the show-through removed image with respect to the image transformed by said coordinate system transformation unit.

23 A color image processing apparatus comprising:

5 an edge detection means for detecting an edge in a digital color original image obtained by digitally inputting a single side of a document color-printed on both sides of paper;

10 a background color estimation means for estimating a background color of said paper or a background color image on said single side with respect to a low-intensity portion of said detected edge; and

15 an image replacement means for replacing the low portion of the edge intensity as a component corresponding to the show-through with said estimated background color or background color image in said original image,

wherein said image replacement means removes said component corresponding to the show-through to generate said show-through removed image.

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24. The color image processing apparatus according to claim 23 wherein said edge detection means calculates edge intensity from each component of an image in which the edge is detected, and detects the edge considering a correlation
25 between the respective edge intensity of said components.

25. The color image processing apparatus according to claim 23 wherein said edge detection means comprises a binarization means for binarizing the edge intensity, said background color estimation means comprises:

in edge distribution in which a pixel with the edge intensity higher than a threshold is obtained as an ON pixel and a pixel with the edge intensity lower than the threshold is obtained as an OFF pixel,

a window setting means for setting a window of a predetermined size in a region of said OFF pixels;

a color clustering means for classifying the pixels within each of said windows set by said window setting means into two colors; and

an estimation means for estimating a color with higher brightness of said two colors as a background color, and

said image replacement means comprises a pixel replacement means for replacing the color of the pixels within each of said windows with said estimated background color.

26. The color image processing apparatus according to claim 25 further comprising:

a horizontal run formation means for forming a run in each line in the horizontal direction in the region of

said OFF pixels; and

a vertical run formation means for forming a run in each line in the vertical direction,

wherein said background color estimation means
5 estimates said background color or background color image using the horizontal (or vertical) runs formed by said horizontal run formation means (or vertical run formation means), further estimates a background color or a background color image using the vertical (horizontal) runs formed by
10 said vertical run formation means (or horizontal run formation means) with respect to said estimated background color or background color image in the horizontal (or vertical) direction, and

said pixel replacement means replaces the pixels of
15 said original image corresponding to said OFF pixels with pixels of said estimated background color or background color image in the vertical (or horizontal) direction.

27. The color image processing apparatus according to
20 claim 25, wherein said binarization means has an automatic threshold setting means which statistically analyzes the distribution of the edge intensity and automatically sets the threshold.

28. The color image processing apparatus according to claim 25, wherein said binarization means has a threshold setting means by which a user sets the threshold according to a degree of show-through or paper quality.

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29. The color image processing apparatus according to claim 23 further comprising:

an edge determination means for detecting an edge of said show-through removed image by said edge detection means, compares said detected edge of the show-through removed image and the edge distribution of said original image, and determines an edge not existing on said original image; and

a repetition means for generating again a show-through removed image about the periphery of the edge not existing said original image in said show-through removed image.

30. The color image processing apparatus according to claim 29, wherein said edge determination means subtracts edge intensity calculated in said original image from edge intensity calculated in said show-through removed image at each pixel, and determines any value higher than a predetermined threshold, in said show-through removed image, as an edge not existing in said original image.

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31. The color image processing apparatus according to claim 29 wherein said repetition means sets the size of said window to a smaller value than that in the previous processing when a show-through removed image is again
5 generated.

32. The color image processing apparatus according to claim 23 further comprising:

an image reduction means for generating a reduced
10 original image with low resolution from said original image;

a show-through region estimation means for calculating a difference between a show-through removed image generated with respect to said reduced original image and said reduced original image to estimate a show-through region; and

15 a pixel allocation means for allocating pixels of said show-through removed image, that correspond to said estimated show-through region, onto said original image with the original resolution.

20 33. The color image processing apparatus according to claim 23 further comprising:

a coordinate system transformation means for transforming the color coordinate system of said original image or said reduced original image to another color
25 coordinate system such as a YCbCr coordinate system or a

pseudo KL color coordinate system, in which the components are highly independent from one another; and

a coordinate system reverse transformation means for performing transformation reverse to said transformation
5 on the show-through removed image with respect to the image transformed by said coordinate system transformation means.

34. A computer-readable recording medium storing a computer program containing instructions which when
10 executed realizes the steps of:

edge-detection of a digital color original image obtained by digitally inputting a single side of a document color-printed on both sides of paper;

estimating background color of said paper or
15 background color image on said single side with respect to a portion with low intensity of said detected edge;

performing color threshold processing in which said portion with the low edge intensity as a component corresponding to the show-through is replaced with said
20 estimated background color or background color image in said original image; and

generating a show-through removed image as an image from which the component corresponding to the show-through has been removed.